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NEUTRALIZATION OF THE POLLUTED SOIL BY A COMPOSTING METHOD

Abstract. As the world population grows and, hence, the intensity of livestock production increases, great volumes of organic wastes produced globally pose a serious problem, and are the major source of environmental pollution. These wastes require large storage areas, emit ammonia and foul odor, contaminate groundwater, and pose a significant problem for human health. Certain methods for managing these wastes can be used to convert them into an efficient and safe soil fertilizer.

Keywords: vermiculture, Californian red worms, vermicompost, biohumus, agricultural wastes, heavy metals, coprolites.

Intriduction. One of the greatest problems that the world is facing today is that of environmental pollution, increasing with every passing year and causing grave and irreparable damage to the earth. Environmental pollution consists of five basic types of pollution, namely, air, water, soil, noise and light. [1-6]. Soil pollution, which can also be called soil contamination, is a result of acid rain, polluted water, fertilizers etc., which leads to bad crops. Soil contamination occurs when chemicals are released by spill or underground storage tank leakage which releases heavy contaminants into the soil. These may include hydrocarbons, heavy metals, MTBE, herbicides, pesticides and chlorinated hydrocarbons. **Bioconversion**, also known as *biotransformation*, is the conversion of organic materials, such as plant or animal waste, into usable products or energy sources by biological processes or agents, such as certain microorganisms. Biohumus positively effects processes of seed germination and promotes more intensive growth of plants. This fertiliser protects a germinating crop from illnesses, while bioactive substances stimulate development of the root system and matter intake, so the plant grows stronger, more resistant to diseases and pests. Also, the plants become more patient of unfavourable meteorological conditions and more resistant to low temperatures and droughts. Biohumus improves soil structure and moisture regime without degrading humus layer, unlike in cases when mineral fertilisers are used. All this contributes to extra yield and higher quality of the crops [7–11].

When optimizing the function of agrocenoses, one needs to compensate for the biocenotic links that have been lost. One of the ways to solve this problem is to artificially restore the individual links of the agro-ecosystem without complete restoration of the species diversity of soil biota. This can be performed by vermicultivation, when the missing link (humified organic matter) is produced under artificial conditions [12]. Biohumus enhances the crop capacity by 20–30% and improves the quality of agricultural products. Nature is a wonderful thing and when we make compost all we are doing is speeding up the eco systems natural process of decomposition. The end result produces a rich compost that helps us produce more vegetation.

To achieve this we systematically apply layers of bio degradable material in a composter so that nature can begin its work in breaking down the waste into compost.

Moreover, the product does not have poignant foul odor. The microflora of the ready-to-use compost is richer than that of fertile soils, and manifold higher than that of contaminated soils. Thus, composting takes considerably a shorter time than natural neutralization of toxic materials does [13].

One of the actual problems of vermicultivation in West Siberian region is the winter cultivation of worms. The paper deals with the influence of psychrophilic conditions of vermicultivation on the number of the basic ecological-trophic groups of microorganisms in organic substrate and on the quality of vermicompost. Vermicompost being used at the amount of 6–10 tons/ha abruptly increases soil fertility. It has been found that when the worms disintegrate wastes to the paste-like state, they form excellent conditions for the development of various microorganisms inhibiting the reproduction of pathogenic bacteria (in particular, of *Salmonella*). The researchers have drawn attention to the fact that the microorganisms contained in vermicompost facilitate the conversion of the toxic forms of heavy metals to immobile com compounds. It is extremely important, since the introduction of vermicompost to the soils around big cities, industrial plants, and places, where a lot of mineral fertilizers and pesticides were used, will promote the sanitation of these soils and the environment in general.

At the time of adaptation of cattle to new Californian worm waste (with the transition to svinyak mullein, litter, etc., the use of water from another source), the majority of adult worms may die in California, not coping with the new food. This is subject to all species and subspecies of worms. However, juveniles can easily adapt to new food, begin to mature and breed - the adaptation is complete. The process of adaptation to the new waste could take 2 - 4 months old. If the worms go after moving to the same food, the adaptation takes place with minimal losses [14–16]. The Californian red worm differs from the other species by its ability to process all types of organic matter, high breeding performance (by over 100 times) and life span (by 4 times) as compared to the common earthworms. Within two months, the population of the Californian red worms (30– 50 thousand worms; biomass being approximately 4 kg/m^2) can process 300–400 kg of stable manure per m^2 of the special plantation, converting it into high-efficiency humic fertilizer. In addition, the biomass of living worms is the valuable natural food for farm birds and animals, as well as for pond fish. Furthermore, worms are used to produce valuable protein flour and preserved food for domestic and fur-bearing animals.

After a patent has been obtained, the Californian red worms started to be cultured in large American specialized farms. Thus, the German government has started to subsidize their agricultural manufacturers according to a specialized program encouraging them not to use pesticides and chemical fertilizers but to use the biological methods of producing crops using Californian red worms.

The organic wastes lose the foul odor and are converted into high-grade organic fertilizer rather quickly as worms breed there. Vermicultivation increases the humification coefficient of the organic matter 1.5–2-fold as compared to the conventional composting [17–20].

Many gardeners compost both yard waste and kitchen waste with compost piles, sheet composting or some other method during the growing season. Fortunately, very little yard waste is generated during winter months when cold temperatures make composting difficult. However, usable kitchen waste is constantly being generated and must be disposed of. Vermicomposting is the process of using worms and micro-organisms to turn kitchen waste into a black, earthy-smelling, nutrient-rich humus.

The present work was aimed at studying the potential of adaptation of the Californian red worms and using them to manage wastes from agricultural farms (differing by their properties and composition) with some domestic wastes added (kitchen wastes, paper, sawdust, garden wastes, etc.).

Materials and methods. Californian red worms and various disintegratable organic wastes, such as pig, horse, camel, sheep, and goat manure obtained from the cattle farms, kitchen wastes, sawdust, crop wastes from the vegetable garden, and sierozem soil, were used in the experiments.

Five wooden boxes with holes in the bottom were filled with organic (livestock and domestic) wastes (25–30 cm height) to be used as food for the Californian red worms and with a small amount of regular garden soil (5–7 cm). The mixture was then slightly compacted, intermixed, and moistened to 70–80%, ensuring good air permeability. First, a cupped hand of Californian red worms was placed on the surface of the substrate. After the worms buried themselves in the mixture, another cupped hand of worms was added (Figure). The boxes containing the worm mass and wastes were kept under dark conditions at 15–18 °C.

Waste mixture in the boxes

Results and discussion. Environmentally safe organic fertilizer Biohumus used to increase the soil fertility and yield of all agricultural cultures is a result of bio processing of livestock and poultry farming waste by the red Californian worm. Coprolite (or Biohumus) is a dry organic loose and dispersible fine-granulated mass of blackish brown colour of average chemical composition in table 1 lists the main nutrients present in different types of manure.

The studies demonstrated that the vermicomposts differed significantly by nutrient contents and properties of their microbial communities. After the worms have ingested fragments of organic matter, they transform it in their digestive tract, and then release it as coprolites (fossilized feces). Due to their properties, coprolites improve the soil structure by enveloping soil walls with mucus, which prevents it from being washed out by water. Furthermore, coprolites change the biochemical composition of the soil. The content of biological nitrogen, phosphorus, and potassium is 5, 7, and 11 times, respectively, higher than that in the surface layer of fertile garden soil. A great amount of calcium is concentrated in coprolites, ensuring the good water-stable structure and high water retentivity. In addition, calcium reduces the acidity of the environment and establishes conditions that impede the development of plant diseases (such as fusarium disease, mildew, bacteriosis, etc.). Furthermore, beneficial microflora is intensively developed near coprolites. All these factors eventually improve biohumus and soil composition. Protease, a component of the worm biomass, exhibits a biostimulating effect, enhances food assimilability in worms, accelerates their growth, and activates physiological and biochemical processes occurring in their organism. Like many other living organisms, the Californian red worms enrich soil in macro- and micro-elements, growth substances, and antibiotic agents.

When the worms process a mixture consisting of different wastes and manure, they give rise to a dry fertilizer with organic matter content of 25–40% and higher (on dry basis). This fertilizer contains 1% of nitrogen, phosphorus, and potassium, as well as numerous microelements that are needed for plant growth. Worm boxes can be purchased or made. Plastic storage containers are convenient and come in a variety of sizes. These containers are easily transported and are a nice alternative to heavier wood bins. Many people choose to have several small bins as opposed to one heavier, large wood bin. Small bins work best in homes, apartments and school classrooms. They are easy to tuck under desks, place below kitchen sinks and keep out of the way in laundry rooms.

As compared to the conventional strategy of manure composting, processing of the organic matter by worms allows one to increase the humification coefficient of the organic matter by 1.5–2 times [20]. The results can be seen by comparing the properties of manure and biohumus, an environmental-friendly fertilizer.

The resulting biohumus contains biologically active sub-stances that accelerate seed germination and striking roots in seedlings, as well as enhance the plant disease resistance. The introduction of biohumus to the soil prevents its oversaturation with individual types of nutrients (as it frequently occurs when large amounts of manure and regular compost are introduced), crop lodging, and other negative effects [21]. Finally, biohumus “rejuvenates” soil. The crops culti- vated in soil fertilized with biohumus contain almost no nitrates and heavy metals. Biohumus contains all the com-pounds required for plant nutrition in the well-balanced and easily digested form. The chemical composition of biohumus is listed in Table.

Chemical composition of biohumus

Component	Quantity
humic acids	6-18%
pH	6.5-7.2%
total nitrogen (A)	0.9-3%
phosphor (P)	0.9-2.5%
potassium (K)	0.6-2.5%
calcium (Ca)	4.5-8%
magnesium (Mg)	0.5-2.3%
iron (Fe)	0.5-2.5%
copper (Cu)	3.5-5.1 mg/kg
manganese (Mn)	60-80 mg/kg
zinc (Zn)	28-35 mg/kg
Bacterial flora	Up to 20 000 billion colonies per 1 g of biohumus
Moisture	30-50%
Dry organic substance (close to soil humus by the composition)	30-70%

Humic acids add the special value to biohumus playing a very important role in biosphere due to their good accumulative capability. Well balanced with nitrogen, phosphor, potassium, and microelements the nutritive substances dissolve gradually and provide their prolonged consumption by roots. Biohumus also demonstrates bactericidal properties for 5 years, contains bio stimulators and ferments, is environmentally safe and has no smell. It is able to "bind" the radioactive particles in the soil and organic waste and to limit the nitrates and heavy metals entering the plants.

In comparison to the traditional organic fertilizers usage biohumus (coprolite) is 5–10 times effective Depending on the type and fertility of soil the 3-10 tones of Biohumus applying per 1hectare increases the maize and other grain cultures yield by 30-40%; potatoes and vegetable yield – by 70%. It is very important that Biohumus application improves the quality of agricultural production – the content of proteins in grain, sugar in root - crops, starch in tubers, vitamins in fruits, berries and vegetable increases by 15-45%.

The received production is environmentally safe concerning nitrates, chlorine components and other harmful substances content. Biohumus (coprolite) is applied both locally at planting of seeds and by surface spreading with following harrowing and cultivation. Biohumus is highly effective for barren and polluted soils. The product is certified, every consignment of product will go through laboratory analyses on chemical composition.

Our data obtained in the experiments focused on the effect of moisture content in the environment on adaptation of the Californian red worms to substrates based on cattle manure have demonstrated that the moisture content of the substrate has to be within the range of 75–80%. By the end of exposure, the population density of the Californian red worms in the above experimental variants at optimal temperature was 16 worms/ dm^3, and a maximum number of cocoons could be observed. Thus, in the substrate variant with 78-82% moisture, the population density was 9 worms/dm^3 higher than that in the variant with 40–55%, 4 worms/dm^3 higher than for substrates with 60–65%, and 2 worms higher than for substrates with 65–70%.

The results of our studies have demonstrated that the products obtained by processing cattle and other organic substrates by worms are characterized by a high content of nutrients and finely dispersed, homogeneous, and of stable macrostructure. The total nitrogen content in vermicompost samples produced by processing organic substrates with the worms fluctuated from 1.2 to 1.5%; contents of P_2O_5 and K_2O fluctuated from 4.2 to 5.1% and from 0.5 to 1.1%, respectively (on a dry basis). The tendency towards better aggregation of vermicompost is observed with increasing fraction of the filling agent in the substrates being processed. Thus, the structural coefficient of the vermicomposts varied from 80.2 to 89.2%, while that in the household compost was 55.7%.

Conclusions.

1. Different rates of dry biohumus did not have any impact on biometric indicators of the wheat (number of the germinated plants, plant height, length of the stem and the wheatear). The number of the productive stems mostly increased using the rate of biohumus 0.5 t ha^{-1}. Fertilization rate, most favourable for the number of grains in the wheatear, was 1.5 t ha^{-1}. The highest weight of one thousand grains was observed after fertilization with biohumus 1.0 t ha^{-1}, and highest yields were received after the wheat had been fertilized with biohumus 0.5 t ha^{-1}.

2. Fertilization with dry biohumus had a positive effect on the level of proteins, sedimentation and gluten in the grains of the winter wheat. According to the quality requirements for food grains, they corresponded to Classes II and III of wheat grains purchased.

3. The rate of dry vermicompost (1.5 t ha^{-1}) added locally, marginally increased the levels of mobile potassium K_2O, total N, total C, exchange Ca and exchange Mg, but had no influence on other researched agrochemical indicators – mobile P_2O_5, mobile Fe, mobile Cu and mobile Zn.

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ЛАСТАНҒАН ТОПЫРАҚТЫ ВЕРМИКОМПОСТТАУ ӘДІСІМЕН ЗАЛАЛСЫЗДАНДЫРУ

Аннотация. Қоршаған ортаға антропогендік әрекеттің әсері жылдан жылға үздіксіз жоғарлауда. Бұл әрекеттің аса жағымсыз нәтижесінде топырақ жүйесіне әр түрлі улы заттар еніп, химиялық, радиациялық және т.б. ластаудың түрлері пайда болады. Топырақты ластайтын және қауіптілігі жоғары заттарға мұнай өнімдерінің қалдықтары, ауыр металдар, радиоактивті бөлшектер және т.б. экотоксиканттар жатады. Осы ластағыштардың шығу көздері өндірістік кәсіпорындар, көлік, энергетикалық кешендер, ауылшаруашылық пен көптеген басқа да салалар болып табылады. Сондықтан, ластанған топырақты вермикомпосттау әдісімен тазалау экологиялық мәселелрді шешудегі тиімді жолдарының бірі болып табылады.

Түйін сөздер: вермиағзалар, қызыл калифорниялық құрттар, вермикомпост, биогумус, ауылшаруашылық қалдықтары, ауыр металдар, капролиттер.

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ОБЕЗВРЕЖИВАНИЕ ЗАГРЯЗНЕННОЙ ПОЧВЫ МЕТОДОМ ВЕРМИКОМПОСТИРОВАНИЯ

Аннотация. Представлены результаты исследований по способу биопереработки различных органических отходов путем вермикультивирования по обезвреживанию почвы. В данной научной работе на основе проведения теоретических и экспериментальных исследований, базирующих на утилизации отходов животноводческих хозяйств и различных бытовых отходов с помощью красных калифорнийских червей, выявлена высокая эффективность применения продуктов вермикультивирования. Проведенный в работе анализ эффективности заключается в решении проблемы по утилизации органических отходов с получением экологически чистых органических удобрений (биогумуса), биомассу червей как высококачественного белкового продукта и выращивания качественной сельхозпродукции.

Ключевые слова: вермикультура, красные калифорнийские черви, вермикомпост, биогумус, сельхозотходы, тяжелые металлы, капролиты.